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PATENT SPECIFICATION

(11) 1 509 185

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(21) Application No. 19297/74 (22) Filed 2 May 1974
(23) Complete Specification filed 4 Aug. 1975
(44) Complete Specification published 4 May 1978
(51) INT CL² F01D 5/22
(52) Index at acceptance F1T 3A1 3B 3C3
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(19)

(54) IMPROVEMENTS IN AND RELATING TO FLUID DRIVEN TURBO MACHINES

(71) We, REYROLLE PARSONS LIMITED, a British Company, of P.O. Box 1NS, Cuthbert House, All Saints, Newcastle Upon Tyne, NE99 1NS, formerly of Hebburn, Co. Durham, NE31 1JP, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the rotor blades of turbo machines and is particularly, although not exclusively, applicable to steam turbines of the axial flow type.

In large diameter rotors, especially in the final low-pressure stages of steam turbines variable forces are imposed on the blades inducing blade vibration and thus adjacent blades are normally connected together at their end regions in order to increase the blade natural frequency and avoid vibration resonance.

Various means have been adopted and are in general use, these include arrangements of lacing wires, cover bands and rigid coupling pins and these solutions have in general succeeded in preventing resonance and reducing vibration and aerodynamic stresses to reasonable limits.

However, with the advent of increasingly larger output machines the diameter of rotor blades is such that whilst present solutions may be mechanically adequate they have not generally taken into account either the aerodynamic effects on the flow pattern of the fluid medium or the losses or blade tip leakage sealing. These latter factors involve considerable stress and assembly problems.

The object of this invention is to provide means for securing the rotor blade tips such that in addition to reducing aerodynamic losses and providing improved sealing of the radial tip clearance, they provide a mechanical design able to withstand the large centrifugal loads without creating unduly high or complex stresses in the components involved. The invention also provides protection against vibratory stresses in the blades, accommodates thermal expansion between the rotor and the blades, and prevents untwisting of the blades under the action of centrifugal load. The invention also provides a mechanical solution which facilitates assembly.

The present invention consists in a fluid driven turbo machine in which each blade is provided with a pair of integral shoulder portions, one located on each side of the blade at or near the end tip region, the shoulders between adjacent blades being spatially separate but bridged by means of a trough-shaped coverband which engages adjacent blade shoulders to form a fluid-seal at the end tip region, wherein adjacent rotor blades are coupled together by means of a coupling member which in operation becomes loaded in tension to prevent untwisting of the blades under the action of centrifugal load, the said coupling member being connected to the leading edge of one blade and to the trailing edge of the adjacent blade.

The coverband may form the coupling member and be connected to the blade shoulder portions through the base of the coverband by means of coupling bolts, screws, rivets or the like.

Alternatively, a single tie-bolt may form the coupling member, and the coverband may be provided with a diagonal web portion through which the single coupling bolt passes, which web serves to retain the coverband whilst the machine is stationary.

As a further alternative, the coverband may be provided with a pair of diagonal aligned bracket web portions through each of which passes a coupling bolt to form the coupling connection and also retain the coverband.

The invention will now be described by way of example only with reference to the accompanying drawings, in which:

Figure 1*a* shows a plan view of a coverband fixing arrangement for the blades of the rotor for an axial flow turbo machine;

Figure 1b shows a side elevation of the end region of one blade of the embodiment shown in Figure 1*a*;

Figure 1*c* is a perspective view of the coverband of the embodiment shown in Figures 1*a* and 1*b*;

Figures 1*d* & 1*e* show alternative forms of fixings adopted for the construction shown in Figures 1*a*—1*c*;

Figure 2*a* is an alternative embodiment for the arrangement shown in Figure 1*a*;

Figures 2*b*, 2*c*, 2*d* & 2*e* show alternative arrangements corresponding to Figures 1*b*, 1*c*, 1*d* and 1*e* respectively; and

Figures 3*a*, 3*b*, 3*c*, 3*d*, & 3*e* show an alternative embodiment corresponding to Figures 1*a*, 1*b*, 1*c*, 1*d* and 1*e* respectively.

In the embodiments shown with reference to Figures 1, 2 and 3, alternative embodiments in accordance with the invention are shown in which the rotor blades for an axial flow turbo machine are connected to adjacent blades.

In all embodiments the same numerals are used for parts having the same function and in all a plurality of blades 1, two only of which are shown, are provided with integral shoulder portions 2 on each side of a single blade. Adjacent blades 1 are connected by trough shaped coverbands or shrouds 3 each having a base 3*f* and upstanding webs or walls 3*g*, 3*h*. It should be noted that in plan the coverband is of rhombic form.

In Figure 1 the coverband 3 is fixed to shoulders 2 by rivets 4*a*, as shown in Figure 1*d*, or screws 4*b*, as shown in Figure 1*c*. Rivets, 3*m* and 3*n* which are integral with the shroud 3, passing through holes 3*k*, 3*l* in side walls 3*h*, 3*g* may also be employed in addition to the rivets or screws illustrated in Figures 1*d* and 1*e*.

Thus the centrifugal torque exerted by each blade is transmitted to adjacent blades 67 the coverbands 3 and the fixing means, i.e. rivets 4*a* or screw 4*b*, which permit angular changes in the coverbands are loaded in shear.

Figures 2*a*, 2*b*, 2*c*, 2*d* and 2*e* differ from the construction shown in Figures 1*a* to 1*e* only by the nature of the connections between the coverband 3 and the adjacent blades 1. In this case the link is provided by a single bolt 5 and nut 6 shown in Figure 2*d* or tie rod 10 welded to adjacent shoulders 2. In this embodiment the coverband 3 is provided with an integral rib 7 as shown in Figure 2*c*. In assembly the bolt 5 or tie 10 would be threaded through the hole in rib 7 to prevent the coverband falling off when the wheel is stationary. This arrangement has the advantage of reducing the centrifugal bending stress levels in the bolt 5 or tie 10 when the wheel is rotating by providing a simple support for this highly stressed member. In this embodiment it may be necessary, in certain instances, to locate the shroud in a tangential direction, in which case additional rivets or screws may be employed to connect the side walls 3*h* 3*g* to the shoulders 2 in a similar manner to that shown in Figures 1*a* and 1*c*, but in this instance adequate clearances should be provided to prevent redundant stress problems in the shroud.

In the embodiments shown in Figures 3*a*, 3*b*, 3*c*, 3*d* and 3*e* the arrangement is such that the rivets 8*a* shown in Figure 3*d* or screws 8*b* as shown in Figure 3*e* are subject to combined tensile and bending loads. In this embodiment an additional bracket 9 integral with the shroud 3 is provided to transmit the force.

In all of the embodiments, during assembly provision is made for sufficient clearance between the coverband and blades, coverband and rivets or screws and blades and the tie bolts. Some of these clearances would close up under the action of centrifugal forces, others would permit certain relative movement of mating components.

The main features of the embodiments are:—

(1) the centrifugal loading exerted by the coverband components is carried by the blading without the use of rivets, screws, shear pins, etc. It has been done by providing integral shoulders on the blades, and in this manner the centrifugal force is evenly distributed on the interface between the shoulders and the comparatively light shroud/coverplate. This interface pressure creates frictional forces when relative movement between the components takes place and provides frictional damping for vibratory movements of the blades and coverband;

(2) the bolts, screws or rivets are used only to:—

(a) prevent the blades untwisting under the action of centrifugal torque, which is effected by connecting the point near the trailing edge of each blade to a point near the leading edge of the adjoining blade, the connection being made to a portion of the blade locally strengthened by shoulders. The arrangement in all cases involves reduction of centrifugal stress in the tie or shroud by the method outlined in (1) and furthermore the tie constitutes an integral part of the coverband/shroud;

(b) prevents the shrouds falling off when the wheel is not rotating;

(3) components are assembled with suitable clearance allowing certain degree of movement arising from blade extension due to stress or thermal effect;

(4) the assembly provides an effective tip leakage seal and may be adopted to suit any aerodynamically required annulus shape.

The advantage of the solution lies mainly in the combination of a simple mechanical construction, together with the aerodynamical improvements to the flow path which would be required in a large low-pressure steam turbine.

WHAT WE CLAIM IS:—

1. A fluid driven turbo machine in which each blade is provided with a pair of integral shoulder portions, one located on each side of the blade at or near the end tip region, the shoulders between adjacent blades being spatially separate but bridged by means of a trough-shaped coverband which engages adjacent blade shoulders to form a fluid-seal at the end tip region, wherein adjacent rotor blades are coupled together by means of a coupling member which in operation becomes loaded in tension to prevent untwisting of the blades under the action of centrifugal load, the said coupling member being connected to the leading edge of one blade and to the trailing edge of the adjacent blade.

2. A fluid driven turbo machine as claimed in Claim 1 in which the coverband forms the coupling member and is connected to the blade shoulder portions through the base of the coverband by means of coupling bolts, screws, rivets or the like.

3. A fluid driven turbo machine as claimed in Claim 1 in which a single tie-bolt forms the coupling member.

4. A fluid driven turbo machine as claimed in Claim 3 in which the coverband is provided with a diagonal web portion through which the single coupling bolt passes, which web serves to retain the coverband whilst the machine is stationary.

5. A fluid driven turbo machine as claimed in Claim 1 in which the coverband is provided with a pair of diagonal aligned bracket web portions through each of which passes a coupling bolt to form the coupling connection and also retain the coverband.

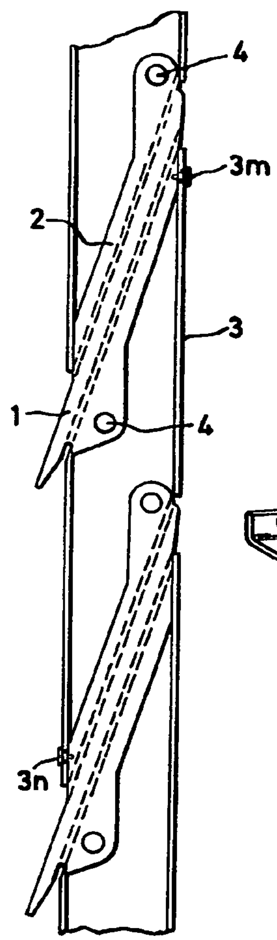
6. A fluid driven turbo machine substantially as described with reference to the accompanying drawings.

MARKS & CLERK.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1978.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1 509 185 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*
SHEET 1

FIG.1a.



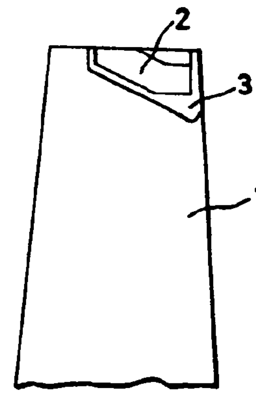


FIG.1b.

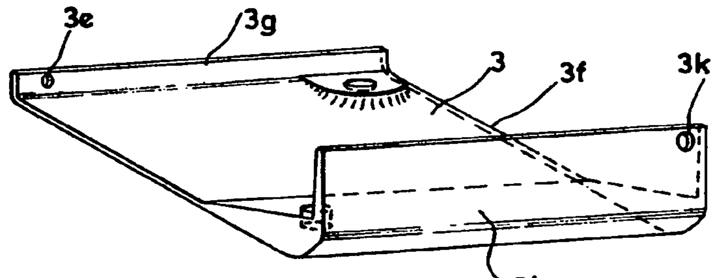


FIG.1c.

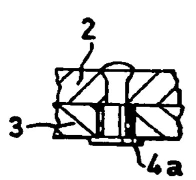


FIG.1d.

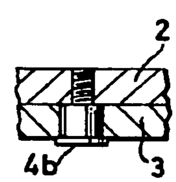


FIG.1e.

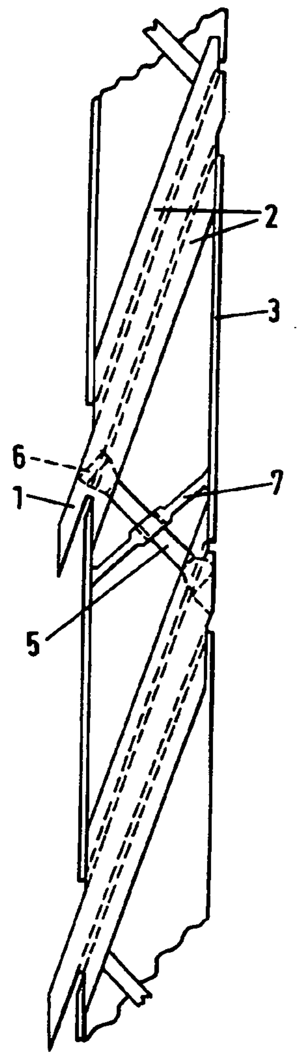


FIG. 2a.

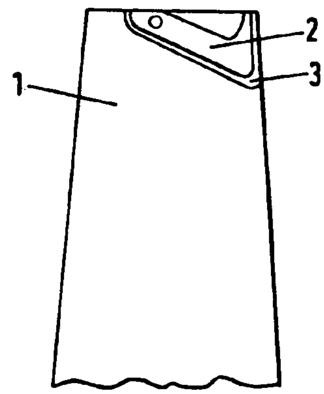


FIG. 2b.

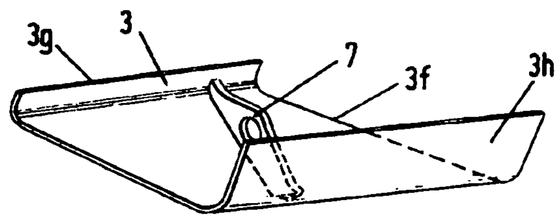


FIG. 2c.

FIG. 2d.

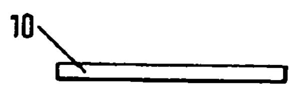


FIG. 2e

1 509 185 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale.*

SHEET 3

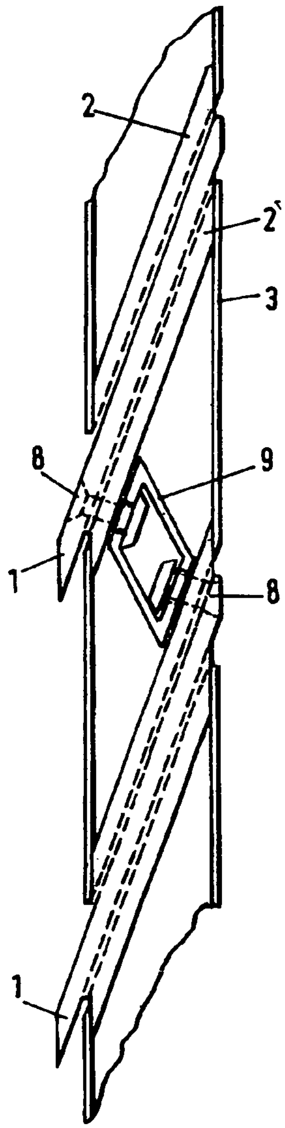


FIG. 3a.

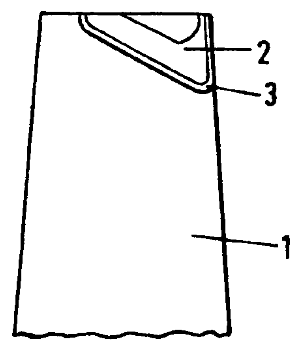


FIG. 3b.

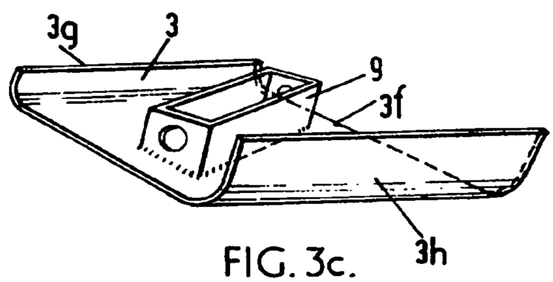


FIG. 3c.

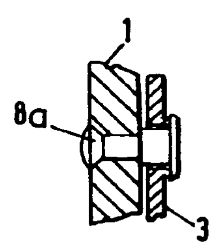


FIG. 3d.

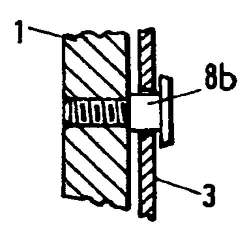


FIG. 3e.